October 21, 1991 SIL No. 459S2

RECIRCULATION PUMP SHAFT CRACKING

The purpose of thisS2 to SIL No. 459 is to inform GE BWR owners of recent shaft cracking in recirculation pumps manufactured by Byron Jackson (BJ) and by Bingham. Results of root cause evaluations and recommended countermeasures also are included. Information in thisS2 is based on work performed by GE Nuclear Energy as well as reports furnished to GE Nuclear Energy by others.

GE BWRs with external heat exchanger BJ pumps

BJ recirculation pumps in many GE BWR/3s, 4s and 5s and two BWR/6s outside the United States have an external tube-in-shell heat exchanger and a solid shaft. Although some shafts are still operating after more than 100,000 hours of service, shaft cracks were detected at all GE BWRs at which shafts were removed and inspected-some with considerably fewer than 100,000 hours of service. Results of crack depth inspections for this class of pump appear in Table 1.

On many occasions, plant personnel have replaced shafts without measuring crack depths. In some of these cases, however, measurements are planned.

GE BWRs with internal heat exchanger BJ pumps

BJ recirculation pumps in three GE BWR/6s have an internal heat exchanger and a welded impeller with a hollow shaft section at the elevation at which the impeller is welded to the shaft. Results of crack depth inspections made for these pumps appear in Table 2. GE BWRs with Bingham recirculation pumps

GE BWRs with Bingham recirculation pumps

Cracking has occurred in Bingham pumps under the shaft thermal sleeve. Results of crack depth examinations of these pump shafts appear in Table 3.

Root cause

Studies have identified the root cause of BJ pump shaft cracking to be fatigue initiated by thermal stresses that occur as cold water leaves the seal cavity and mixes with the hotter, pumped reactor coolant. The combined thermal and mechanical stresses resulting from individual pump service conditions caused the cracks to propagate.

A destructive examination of one Bingham pump shaft was performed. This identified the predominant cause of cracking to be fatigue caused by cyclic thermal stresses.

Recommended countermeasures

1. GE Nuclear Energy recommended shaft vibration monitoring in the original SIL No. 459. Such monitoring has detected cases of severe shaft cracking in time to take corrective actions before shafts severed, which would have caused further damage.

2. SIL No. 459, which addresses only BJ pumps, recommended inspection of shafts with greater than 80,000 hours of service. Such inspections have revealed sufficient shaft damage to require shaft replacement. This recommendation still applies to BJ pumps with external heat exchangers. Owners of GE BWRs with BJ pumps with internal heat exchangers should install vibration monitors and perform inspections more frequently.

   A Sulzer Bingham Technical Advisory recommends inspection of its recirculation pump shafts after 25,000 hours of operation. Sulzer Bingham recommends this inspection schedule for replacement shafts as well as for original shafts.

3. To prevent or minimize shaft cracking, several GE BWR owners have implemented the countermeasures recommended in SIL No. 511, "Reduced Seal Purge Flow for Byron Jackson Recirc Pumps," issued April 30, 1990. These included reducing seal purge and eliminating the cover drain hole. Operation with zero seal purge has been successful in a few early GE BWRs with BJ pumps. This modification may be considered for other BJ pumps if seal performance is acceptable.

4. The following additional improvements also have been made at some GE BWRs:

   o improved shaft surface condition
   o improved balance and alignment

o reduced shaft vibration amplitudes

o Reduced operational transient frequency

5. Replacement components of improved design are available for BJ pumps. These include the following:

o elimination of cover drain hole

o a center drilled hole in shaft for in-situ UT examination

o cover inspection ports

o improvements in gasketing, impeller attachment, bolting and materials.

Table 1-BJ pumps with external heat exchangers

GE BWR type	Hrs of shaft oper.	Yrs of plant oper.	Approx. crack depth	Examination method
BWR/4	26,000	6	0.2 in.	progressive machining
BWR/6	54,000	9	0.1 in.	potential drop method
BWR/6	54,000	9	0.13 in.	potential drop method
BWR/4	70,000	11	0.59 in.	destructive examination
BWR/4	70,000	11	0.6 in.	potential drop method
BWR/4	74,000	12	0.23 in.	potential drop method
BWR/4	74,000	12	0.15 in.	potential drop method
BWR/4	102,000	16	0.13 in.	potential drop method
BWR/4	102,000	16	0.22 in.	potential drop method
BWR/4	116,000	16	0.3 in.	destructive examination

Table 2-BJ pumps with internal heat exchangers

GE BWR type	Hrs of shaft oper.	Yrs of plant oper.	Approx. crack depth	Examination method
BWR/6	30,000	5	0.2 in.	destructive examination
BWR/6	30,000	5	0.16 in.	potential drop method
BWR/6	27,000	5	1.5 in.	see note
BWR/6	27.000	5	1 in.	destructive examination
BWR/6	11,000	1.5	1.5 in.	see note
BWR/6	11,000	1.5	0.2 in.	destructive examination

Note: In these cases there was through wall (partial circumference) cracking, which was detected by vibration instrumentation and confirmed by visual and destructive examinations.

Table 3-Bingham pumps

GE BWR type	Hrs of shaft oper.	Yrs of plant oper.	Approx. crack depth	Examination method
BWR/5	21,000	4	.156 in.	destructive examination
	21,000	4	.340 in.	UT
BWR/5	23,000	4	.410 in.	UT
	23,000	4	.200 in.	UT

To receive additional information on this subject or for assistance in implementing a recommendation, please contact your local GE Nuclear Energy Service Representative.

This SIL pertains only to GE BWRs. The conditions under which GE issues SILs are stated in SIL No. 001R1, the provisions of which are incorporated into this SIL by reference.

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Product reference

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